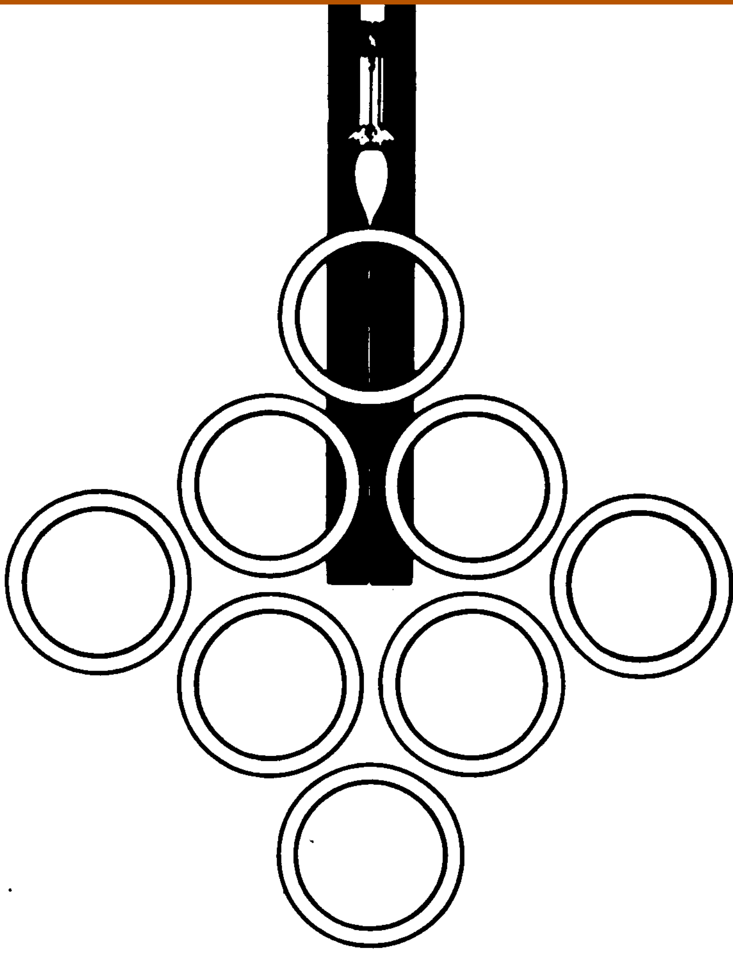

ENGINEERING DEPARTMENT

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FINAL FLIGHT PERFORMANCE PREDICTION FOR SATURN AS-206 (MISSION 276) PROPULSION SYSTEM, S-IB-6 STAGE

SATURN S-IB STAGE AND SATURN IB PROGRAM

SPACE DIVISION CHRYSLER CORPORATION

TECHNICAL REPORT TR-P&VE-68-68

FINAL
FLIGHT PERFORMANCE PREDICTION
FOR
SATURN AS-206 (MISSION 276) PROPULSION SYSTEM
S-IB-6 STAGE

June 15, 1968

Prepared by: G. W. Koser
G. W. Koser
Propulsion and Mechanical
Engineering Section

Approved by: T. W. Loomis, for
C. C. Gage, Chief Engineer
Propulsion and Vehicle
Engineering Branch

Approved by: Claud C. Gage for:
V. J. Vehko, Director
Engineering Department

CHRYSLER CORPORATION SPACE DIVISION - NEW ORLEANS, LOUISIANA

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ABSTRACT

This report covers the prediction of the S-IB-6 propulsion system flight performance and supersedes CCSD Technical Report TR-P&VE-66-38, due to changes in propulsion criteria and launch schedule.

Analyses of the prediction data indicate that inboard and outboard engine cutoffs will occur approximately 137.91 seconds and 140.91 seconds after first motion, respectively. These times are based on defined LOX and fuel load specific weights and stage propellant fill weights for the revised launch schedule for AS-206 (fourth quarter of 1968).

FOREWORD

This report presents the flight performance prediction data for the Saturn AS-206 (Mission 276) Propulsion System, S-IB-6 stage, and is authorized by Contract NAS8-4016 DRL 039, Revision C ~~B~~, Item 35.

The prediction data were determined by simulating the first stage powered flight of the Saturn AS-206 with the Mark IV computation procedure. The data presented in this report supersedes those presented in CCSD Technical Report TR-P&VE-66-38.

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Section 1

SUMMATION

1.1 INTRODUCTION

This report presents the flight performance prediction of the S-IB-6 propulsion system and a discussion of the data and methods used in making the prediction.

The AS-206 configuration used in this prediction is to be part of the Mission 276 dual launch Apollo support mission. AS-206 will carry a Lunar Module as payload to be mated with the Apollo Command Service Module of AS-207.

1.2 OBJECT

The object of this report is to present the predicted performance parameters of the S-IB-6 propulsion system.

1.3 CONCLUSIONS

Analyses of the available data indicate that nominal inboard and outboard engine cutoff (IECO and OECO) will occur approximately 137.91 seconds and 140.91 seconds after first motion, respectively. These times are based on the following assumptions:

a. A nominal fuel load specific weight of 50.25 lbm/ft^3.

b. A nominal LOX load specific weight of 70.574 lbm/ft^3.

c. A liquid level difference of 3 inches between the center LOX tank and the outboard LOX tanks at the time of inboard engine cutoff signal.

d. Stage nominal fill weights of 631,932 pounds of LOX and 278,416 pounds of fuel.

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Section 2

DISCUSSION

2.1 VEHICLE DESCRIPTION

The AS-206 vehicle will consist of the S-IB-6 first stage, S-IVB-206 second stage, the S-IU-206 instrument unit, and an Apollo lunar module payload. The vehicle is scheduled for launch during the fourth quarter of 1968 as part of a dual launch Apollo support mission.

2.2 PREDICTED PERFORMANCE

The predicted performance includes all the latest changes in propulsion and stage criteria that have occurred since the last prediction reported in reference 1.

Changes in criteria from those used in reference 1 are revisions to the H-1 engine table of influence coefficients, Rocketdyne single engine acceptance test data, launch date, axial force coefficients, stage trajectory, and engine performance biasing factors.

Six sets of predictions were made: the nominal case was based on the expected propellant density conditions for the launch month; four cases were based on the 3-sigma propellant density dispersions for that month; and one case represents a minimum residual dispersion.

2.2.1 Nominal Prediction

Specific performance data were recorded on magnetic tapes B5 and B6, reels 3261 and 1208, respectively. These tapes were delivered to CCSD Aerospace Physics Branch (Department 2780). A duplicate copy of the B6 tape (reel 8449), required by the Aero-Astrodynamics Laboratory (R-P&VE-FMT), MSFC, was submitted to the Performance Analysis Section (R-P&VE-PPE), MSFC. The weights cards have been given to the CCSD Weight Control Group (Section 2733) for evaluation.

Weight data are presented in table 1. Stage parameters, including predicted fill weights, ullage volumes, and engine cutoff times, are shown in table 2. Vehicle thrust, specific impulse, fuel flowrate, LOX flowrate, and mixture ratio as functions of flight time, referenced from first motion, are shown in figures 1 through 5, respectively.

LOX and fuel tank ullage pressures, ambient pressure, and LOX pump inlet specific weight as functions of flight time are shown in figures 6 through 8. Representative individual engine performance curves for a typical outboard engine (position 1) as a function of flight time are shown in figures 9 through 13. Average values for many of the parameters appear on these curves. The averages were calculated from first motion to IECO.

2.2.2 Dispersion Cases

In addition to the nominal prediction, five flights were simulated to show the effects of various propulsion performance dispersions. These flights consisted of fuel density dispersions due to 3-sigma prelaunch ambient air temperature and LOX-proximity chilldown rate deviations, LOX density variations caused by 3-sigma deviations in prelaunch environmental conditions, and the effect of a simultaneous fuel depletion and LOX starvation OECO on stage performance. Data obtained from the additional flight simulations are shown in table 2.

The minimum residual dispersion is commonly referred to as the - 3-sigma mixture ratio (EMR) residual propellant dispersion. The data for this dispersion reflects an effective shift of -0.67 percent in propellant mixture ratio while holding the thrust and specific impulse values the same as for the nominal case. The effective mixture ratio shift accounts for consumption of the 1000-pound fuel bias prior to IECO, and an additional 800 pounds of fuel available prior to OECO; as a result, 1800 pounds of additional fuel will be consumed with the nominal LOX consumption. This case simulates a simultaneous OECO signal from the thrust OK pressure switches and the fuel depletion probes.

Data from the propulsion performance dispersion cases are recorded on tapes B5, B6, and B7, which are stored at the Computer Operations Office. The reel numbers of the tapes are as follows:

Condition	Tape B5 Reel No.	Tape B6 Reel No.	Tape B7 Reel No.	Duplicate Tape B6 Reel No.
3-Sigma Low Fuel Density	2716	3000	2738	8908
3-Sigma High Fuel Density	2736	2914	2616	10245
3-Sigma Low LOX Density	0139	4437	5767	3965
3-Sigma High LOX Density	8643	1978	4058	8348
-3-Sigma Mixture Ratio	3749	3932	3583	2617

The weights cards were given to the CCSD Weight Control Group (Department 2753), and tapes B5 and B6 are for use by the CCSD Aerospace Physics Branch (Department 2780). Duplicate copies of tape B6 (listed above) were submitted to the Performance Analysis Section (R-P&VE-PPE) MSFC.

2.2.3 Propellant Usage

The nominal stage fill weights shown in table 3 were determined for a LOX volume of approximately 66,990 gallons, having a specific weight of 75.574 lbm/cu ft, and a corresponding amount of fuel, required for defined simultaneous depletion of consumable propellants, at a specific weight of 50.25 lbm/cu ft (reference 2). The fill weights shown in the table will be required for the depletion of nominally defined consumable propellants.

Variations from the predicted fuel density will require adjustments to the predicted propellant loads to ensure defined simultaneous depletion of propellants. The required propellant loads for any fuel density are presented in figure 14.

A fuel bias of 1000 pounds is included in the fuel load to minimize propellant residuals if there are deviations from the predicted propellant mixture ratio. The fuel bias for this flight is the same as that used for all previous S-IB flights.

The LOX specific weight is based on statistically determined values of wind speed, absolute humidity, ambient pressure, and ambient temperature expected for the launch month. The fuel specific weight was based on the 5-day mean temperature expected for the month of launch during the fourth quarter of the year and an approximate 10-degree chilldown due to LOX exposure. Included in the total exposure time is an estimated 30 minutes of unscheduled holds.

All LOX in the tanks, sumps, and interchange lines (except approximately 3 gallons trapped in the center tank sump) can be consumed. Approximately 75 gallons of the outboard engine suction line LOX volume will also be consumed if the predicted LOX starvation mode of OECO occurs. The remaining LOX in the suction lines is considered as unusable propellant and is shown as LOX residual in table 1.

It is predicted that the fuel level (for the nominal case) at the end of outboard engine thrust decay will be approximately at the bottom of the containers. The fuel in the sumps, interchange lines, and suction lines is shown as fuel residual in table 1.

A portion of the predicted fuel residual is the 1000-pound fuel bias available for consumption prior to IECO. Approximately 800 pounds more of the residual can be consumed prior to OECO if a significantly lower than predicted consumption ratio is experienced. If the predicted performance occurs, this total of 1800 pounds of fuel will not be consumed.

2.2.4 Engine Performance

S-IB-6 is the first S-IB stage that has the 205K thrust H-1 engines. Engine data from Rocketdyne individual engine acceptance tests, the short and long duration stage static tests, and comparison of these data with other H-1 engine data were analyzed to predict stage flight propulsion performance. The various data for S-IB-6 are shown in table 3. A summary of the individual engine data has been made in table 4 by averaging the data from table 3.

Some time after the previous S-IB-6 propulsion system prediction (reference 1), Rocketdyne used the results of a recent gain study (reference 3) to revise the H-1 engine mathematical model used to reduce the Rocketdyne single engine acceptance test data to rated pump inlet conditions (sea level data). The table of influence coefficients (gain table) used in propulsion performance predictions was also revised to be consistent with the results of the gain study and the revised mathematical model. The gain table is also used in the site reduction of the MSFC stage static test firings. The data presented in table 3 is a summation of all S-IB-6 engine site data reduced to standard sea level conditions with the latest mathematical models.

When the stage static test data were reduced with the latest 205K thrust engine gain table, no attempt was made to adjust engine propellant flowrates according to tank discrete probe data. The flowrates quoted for the stage static tests are calculated values that were obtained by the "rpm-match" method of reconstructing stage static test data. This method determines individual engine power levels quite accurately by using measured rpm data which is used as input to the program. The program's calculated rpm values are compared to the measured values and are iteratively changed until the values match. Although this method adequately extrapolates propellant flowrates, the obtained flowrates are not necessarily exact.

The engine histories for the majority of 200K and 205K H-1 engines have indicated an upward shift in performance from Rocketdyne acceptance tests to stage static tests. A further increase from stage static test to flight has occurred for the 200K engine powered stage flights. The stage static tests for S-IB-6, however, exhibited lower performance levels on six of the seven applicable engines* than the Rocketdyne acceptance data; the short duration static test (SA-36) was slightly lower than the Rocketdyne data, but the long duration static test (SA-37) was significantly lower in performance levels. The cause of the lower power levels is not known, but the lower levels are supported by decreases in chamber pressures and pump speeds on these six engines when compared with Rocketdyne data. Although all S-IB flights have exhibited significantly different performances when compared to Rocketdyne data, the differences in performance parameters have been fairly consistent for each flight. One of these differences has been an approximate 0.8 percent upward shift in propellant flowrate mixture ratio. Previous stage static test data, although agreeing more closely with flight results in magnitude, did not have the consistent deviations in performance shown in the acceptance test data.

Since it cannot be definitely concluded that the low power levels of the stage static tests are not valid data, the engine performance characterization determined for S-IB-6 consists of the average of the Rocketdyne acceptance test data, with no power level adjustments but with flowrate adjustments to account for one-half of the mixture ratio shift exhibited during past S-IB flights. The mixture ratio adjustment was made since there is no direct evidence that the shift will not occur during the flight even if the power levels are low. The shift in mixture ratio seen during past flights has a significant effect on stage performance and must be at least conservatively considered in this prediction. Accounting for the one-half of the flight mixture ratio shift resulted in a LOX flowrate increase of 0.2555 percent and a fuel flowrate decrease of 0.165 percent. The predicted individual engine flight data reduced to sea level and the rated pump inlet conditions at 30 seconds after first motion, are shown in table 5 and were used to predict flight performance.

The increases in performance from Rocketdyne acceptance test data to flight data, as noted during past S-IB flights and as discussed above, were increases at a reference time of 30 seconds. The increases in power levels, however, are not constant throughout flight. The shape of this power level shift, referenced to sea level and rated pump inlet conditions, is shown as a percentage of the referenced 30-second sea level thrust in figure 15. The shape of this curve, determined from the past S-IB flights, shows a fairly rapid buildup to quasi-stable conditions at approximately 30 seconds, with a slower buildup thereafter. The prediction for S-IB-6 includes this performance shift. The power level flight performance adjustments, had they been deemed necessary for S-IB-6, would only be used to shift the curve upward.

*Engine 8, H-4071, was replaced after test SA-37 with engine H-4072, due to a crack in a thrust chamber coolant tube.

2.2.5 Engine Cutoff Criteria

The time base two (T_2) cutoff sequence will be initiated when any one of the four liquid level sensors is uncovered. The predicted actuation time is 134.91 seconds after first motion. Liquid level sensors are located in fuel tanks F-2 and F-4 and LOX tanks 0-2 and 0-4. IECO will be signaled by the launch vehicle digital computer (LVDC) 3.0 seconds after initiation of the time base two cutoff sequence.

The OECO signal can be given by the deactuation of two of the three thrust OK pressure switches in any one of the outboard engines, or by one of the fuel depletion probes located in the sumps of fuel tanks F-2 and F-4. The predicted performance is based on the assumption that LOX pump starvation of two of the four outboard engines will occur 3.0 seconds after the IECO signal, and that the OECO signal will be given by deactuation of the thrust OK pressure switches. A fuel depletion OECO can occur if the fuel bias and the fuel between the container bottoms and the depletion probes is consumed prior to a LOX pump starvation. Because of the possible consumption of the fuel between the theoretical tank bottom and the depletion probes, the time between IECO and the OECO can be as much as 4 seconds, and the OECO mode can be either fuel depletion or LOX pump starvation.

The time base two (T_2) sequence, expected to start 134.91 seconds after first motion, is summarized as follows:

T_2 + 0.0 sec -	LVDC activated. T_2 sequence begins with liquid level sensor actuation.
T_2 + 3.0 sec -	IECO signal given by LVDC.
T_2 + 4.5 sec -	Outboard engine thrust OK pressure switches grouped.
T2 + 5.5 sec -	Fuel depletion sensors armed.
T_2 + 6.0 sec -	OECO signal expected due to LOX starvation.

This sequence was determined for the predicted performance with the LOX and fuel liquid level sensors located according to present stage documentation. The sequence separates thrust OK pressure switch grouping from fuel depletion sensor arming in order to minimize the possibility of OECO caused by a premature sensor signal.

Table 1. Weight Breakdown For AS-206 Vehicle

Parameter	Miscellaneous (lb)	LOX (lb)	Fuel (lb)	Total (lb)
Consumption During Ignition and Holddown		11,013	3,237	14,250
Mainstage Consumption		614,057	266,830	880,887
Consumption During Inboard Engine Thrust Decay*		740	1,396	2,136
Consumption During Outboard Engine Thrust Decay*		622	1,348	1,970
Propellant Residual**		2,922	4,897	7,819
Gearbox Fuel Consumption			708	708
GOX Generated During Flight		2,578		2,578
Ice	1,100			1,100
Initial LOX Tank Pressurant	33			33
Hydraulic Oil	28			28
Oronite (Fuel additive for lubrication)	32			32
Initial Weight of Helium in Fuel Tanks	5			5
Initial Weight of Nitrogen and Helium in All Spheres (for fuel container pressurization, S-IB stage purge, etc.)	94			94
Total Upperstage Weight Plus S-IB Stage Dry Weight	385,563			385,563
Total Weight at Ignition Command	386,855	631,932	278,416	1,297,203

* Thrust decay includes propellant below main valves that is not necessarily burned but ejected overboard after valves close.

**The fuel residual includes 1000 pounds for biasing. The bias is available to provide an equal propellant weight at the 3-sigma mixture ratio limits.

Table 2. Stage Parameters For Propulsion Performance Predictions

Parameter	3σ Low LOX Density	3σ High LOX Density	Nominal Prediction	3σ Low Fuel Density	3σ High Fuel Density	* Case 6
Average Fuel Density (lb/ft^3) Average Fuel Temperature (°F)	50.25 60.	50.25 60.	50.25 60.	49.98 71.	50.80 38.	50.25 60.
Total Load LOX Density (lb/ft^3) Mean LOX Pump Inlet Temperature During Flight (°F)	70.287 -290.25	70.785 -293.36	70.574 -291.90	70.574 -291.90	70.574 -291.90	70.574 -291.90
Average Thrust (kips)	1,768.68	1,796.16	1,783.23	1,798.04	1,753.02	1,783.12
Average Specific Impulse (sec)	281.536	282.151	281.886	282.230	281.062	281.863
Average LOX Flowrate (lb/sec)	4,366.86	4,442.72	4,406.62	4,447.13	4,325.80	4,398.22
Average Fuel Flowrate (lb/sec)	1,915.23	1,923.14	1,919.36	1,923.60	1,911.20	1,927.83
Average Mixture Ratio	2.28002	2.31009	2.29583	2.31182	2.26334	2.28139
IECO (sec)	138.628	136.772	137.910	136.625	139.660	137.727
OECO (sec)	142.496	139.916	140.910	139.625	144.178	141.631
Fuel Load (lb)	278,416	278,416	278,416	276,485	282,392	278,416
LOX Load (lb)	631,309	632,205	631,932	631,932	631,932	631,932
Minimum Allowable Fuel Ullage (%)	2.00	2.00	2.00	2.00	2.00	2.00
Nominal Allowable LOX Ullage (%)	1.50	1.50	1.50	1.50	1.50	1.50
Fuel Ullage at Fill (%)	3.71	3.71	3.71	3.87	3.39	3.71
LOX Ullage at Fill (%)	1.20	1.77	1.50	1.50	1.50	1.50

*Case 6 represents the fuel depletion or LOX starvation cutoff mode dispersion.

Table 3. Sea Level Test Data For S-IB-6 Stage Engines

Engine H-7071 Position 1	Static Test Analysis SA-36	Static Test Analysis SA-37	Average Rocketdyne Engine Logs From PAST-076 Program	Prediction*
Thrust (kips)	203.97	202.68	204.84	204.84
Chamber Pressure (psia)	703.05	699.05	705.74	705.74
Specific Impulse (sec)	263.87	262.94	262.81	262.48
LOX Flowrate (lbm/sec)	533.17	531.62	537.70	539.07
Fuel Flowrate (lbm/sec)	239.84	239.20	241.72	241.32
Mixture Ratio	2.2230	2.2225	2.2245	2.2338
Turbopump Speed (rpm)	6687.0	6673.3	6727.1	6727.1
Engine H-7072 Position 2				
Thrust (kips)	202.45	200.41	204.34	204.34
Chamber Pressure (psia)	700.36	693.84	706.10	706.10
Specific Impulse (sec)	262.68	261.14	262.90	262.57
LOX Flowrate (lbm/sec)	531.90	529.57	536.77	538.14
Fuel Flowrate (lbm/sec)	238.83	237.86	240.50	240.10
Mixture Ratio	2.2271	2.2264	2.2319	2.2413
Turbopump Speed (rpm)	6627.1	6606.4	6669.0	6669.0
Engine H-7073 Position 3				
Thrust (kips)	203.93	202.54	204.34	204.34
Chamber Pressure (psia)	705.16	700.86	706.49	706.49
Specific Impulse (sec)	263.55	262.28	262.92	262.59
LOX Flowrate (lbm/sec)	535.18	534.08	537.60	538.97
Fuel Flowrate (lbm/sec)	238.60	238.14	239.61	239.22
Mixture Ratio	2.2430	2.2427	2.2436	2.2531
Turbopump Speed (rpm)	6640.0	6630.3	6661.1	6661.1
Engine H-7075 Position 4				
Thrust (kips)	203.00	199.58	204.54	204.54
Chamber Pressure (psia)	697.30	686.79	702.02	702.02
Specific Impulse (sec)	264.71	262.63	262.47	262.14
LOX Flowrate (lbm/sec)	529.02	524.11	537.79	539.16
Fuel Flowrate (lbm/sec)	237.85	235.80	241.51	241.11
Mixture Ratio	2.2242	2.2227	2.2268	2.2362
Turbopump Speed (rpm)	6645.2	6601.6	6723.1	6723.1

Table 3. Sea Level Test Data for S-IB-6 Stage Engines (continued)

Engine H-4068 Position 5	Static Test Analysis SA-36	Static Test Analysis SA-37	Average Rocketdyne Engine Logs From PAST-076 Program	Prediction*
Thrust (kips)	204.52	202.26	205.22	205.22
Chamber Pressure (psia)	703.64	696.69	705.62	705.62
Specific Impulse (sec)	264.00	262.26	263.46	263.13
LOX Flowrate (lbm/sec)	535.76	533.32	538.95	540.33
Fuel Flowrate (lbm/sec)	238.92	237.91	240.01	239.62
Mixture Ratio	2.2424	2.2417	2.2455	2.2550
Turbopump Speed (rpm)	6718.0	6696.3	6747.3	6746.3
Engine H-4069 Position 6				
Thrust (kips)	206.61	204.77	204.33	204.33
Chamber Pressure (psia)	709.91	704.24	702.93	702.93
Specific Impulse (sec)	264.76	263.67	262.94	262.61
LOX Flowrate (lbm/sec)	539.78	537.12	537.47	538.84
Fuel Flowrate (lbm/sec)	240.59	239.47	239.61	239.22
Mixture Ratio	2.2436	2.2429	2.2431	2.2525
Turbopump Speed (rpm)	6688.9	6665.2	6667.7	6667.7
Engine H-4070 Position 7				
Thrust (kips)	203.26	202.04	204.34	204.34
Chamber Pressure (psia)	696.97	693.23	700.33	700.33
Specific Impulse (sec)	264.71	263.56	263.64	263.31
LOX Flowrate (lbm/sec)	532.14	531.26	537.26	538.63
Fuel Flowrate (lbm/sec)	235.71	235.34	237.83	237.44
Mixture Ratio	2.2577	2.2574	2.2590	2.2685
Turbopump Speed (rpm)	6625.3	6617.5	6670.0	6670.0
Engine H-4072 Position 8				
Thrust (kips)	N/A	N/A	204.03	204.03
Chamber Pressure (psia)	N/A	N/A	697.63	697.63
Specific Impulse (sec)	N/A	N/A	263.37	263.04
LOX Flowrate (lbm/sec)	N/A	N/A	536.00	537.37
Fuel Flowrate (lbm/sec)	N/A	N/A	238.70	238.31
Mixture Ratio	N/A	N/A	2.2455	2.2549
Turbopump Speed (rpm)	N/A	N/A	6647.5	6647.5

*See Section 2.2.4

Table 4. Summary of Sea Level Test Data for S-IB-6 Stage Engines

Average S-IB-6 Engine	Static Test Analysis SA-36	Static Test Analysis SA-37	Average Rocketdyne Engine Logs From PAST-076 Program	Prediction*
Thrust (kips)	203.96	202.04	204.50	204.50
Chamber Pressure (psia)	702.34	696.39	703.36	703.36
Specific Impulse (sec)	264.04	262.65	263.06	262.74
LOX Flowrate (lbm/sec)	533.85	531.58	537.44	538.81
Fuel Flowrate (lbm/sec)	238.62	237.67	239.94	239.54
Mixture Ratio	2.2372	2.2366	2.2399	2.2494
Turbopump Speed (rpm)	6661.6	6641.5	6689.1	6689.1

* See Section 2.2.4

Table 5. Predicted Sea Level Performance of S-IB-6 Stage Engines at 30 Seconds of Flight Time

Parameters	Nominal Value	Engine H-7071 Pos. 1	Engine H-7072 Pos. 2	Engine H-7073 Pos. 3	Engine H-7075 Pos. 4	Engine H-4068 Pos. 5	Engine H-4069 Pos. 6	Engine H-4070 Pos. 7	Engine H-4072 Pos. 8	Vehicle Parameters
Engine Thrust (kips)	205.00	204.84	204.35	204.34	204.54	205.22	204.33	204.34	204.03	1,630.39*
Engine Specific Impulse (sec)	263.63	262.48	262.57	262.59	262.14	263.13	262.61	263.31	263.04	261.62**
Chamber Pressure (psia)	704.71	705.74	706.10	706.49	702.02	705.62	702.93	700.33	697.63	---
Engine LOX Flowrate (lbm/sec)	536.86	539.07	538.14	538.97	539.16	540.33	538.84	538.63	537.37	4,310.5
Engine Fuel Flowrate (lbm/sec)	240.74	241.32	240.10	239.22	241.11	239.62	239.22	237.44	238.31	1,921.4**
Engine Mixture Ratio	2.23	2.2338	2.2413	2.2531	2.2361	2.2550	2.2525	2.2685	2.2549	2.2434**
Turbopump Speed (rpm)	6691.3	6727.1	6669.0	6661.1	6723.1	6746.3	6667.7	6670.0	6647.5	---
Engine Throat Area (sq in.)	204.35	204.35	204.35	204.35	204.35	204.35	204.35	204.35	204.35	---
Engine Expansion Ratio	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	---

*Thrust along longitudinal axis.
**Includes fuel used as lubricant.

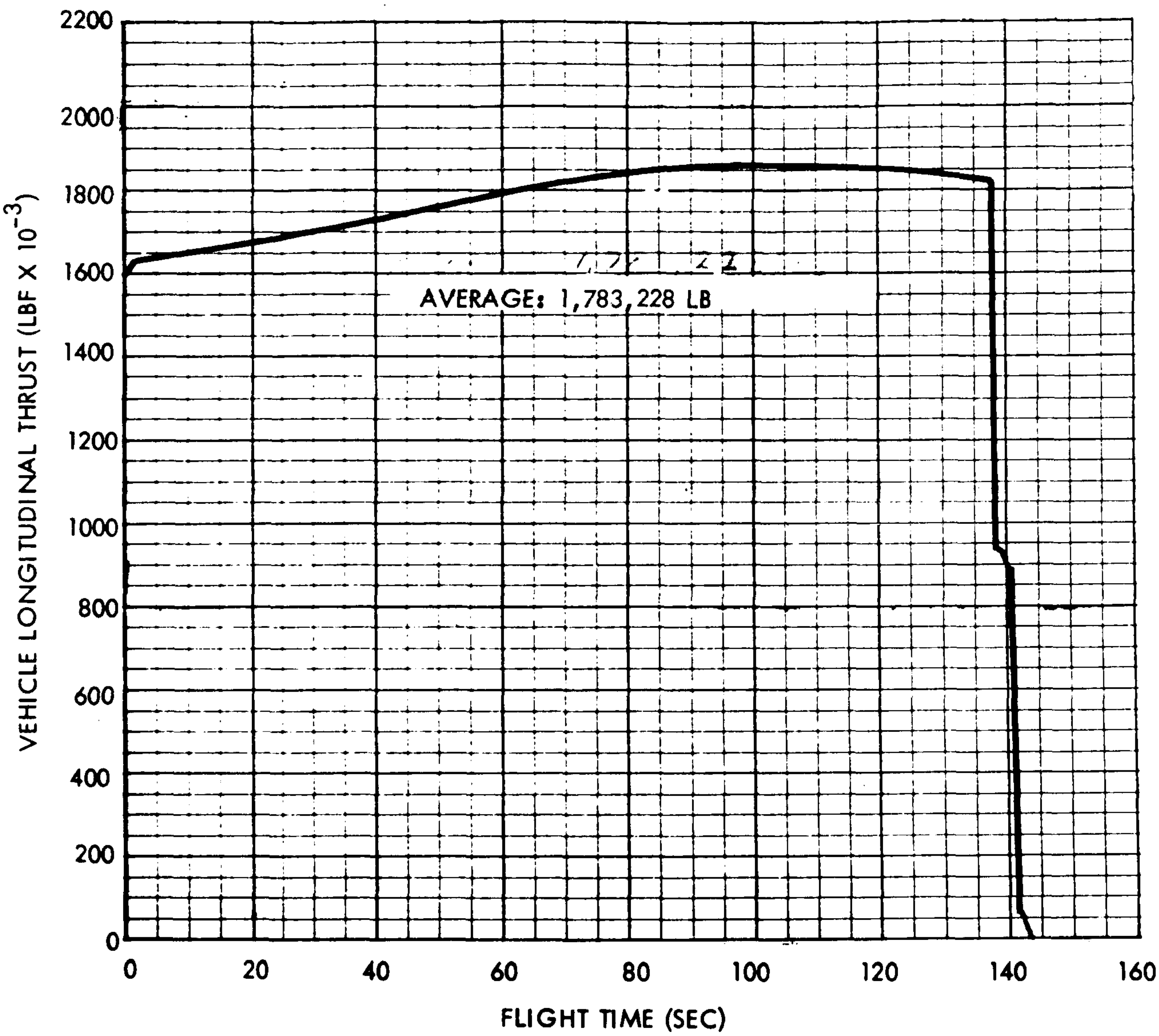

Figure 1. Vehicle Longitudinal Thrust Versus Flight Time

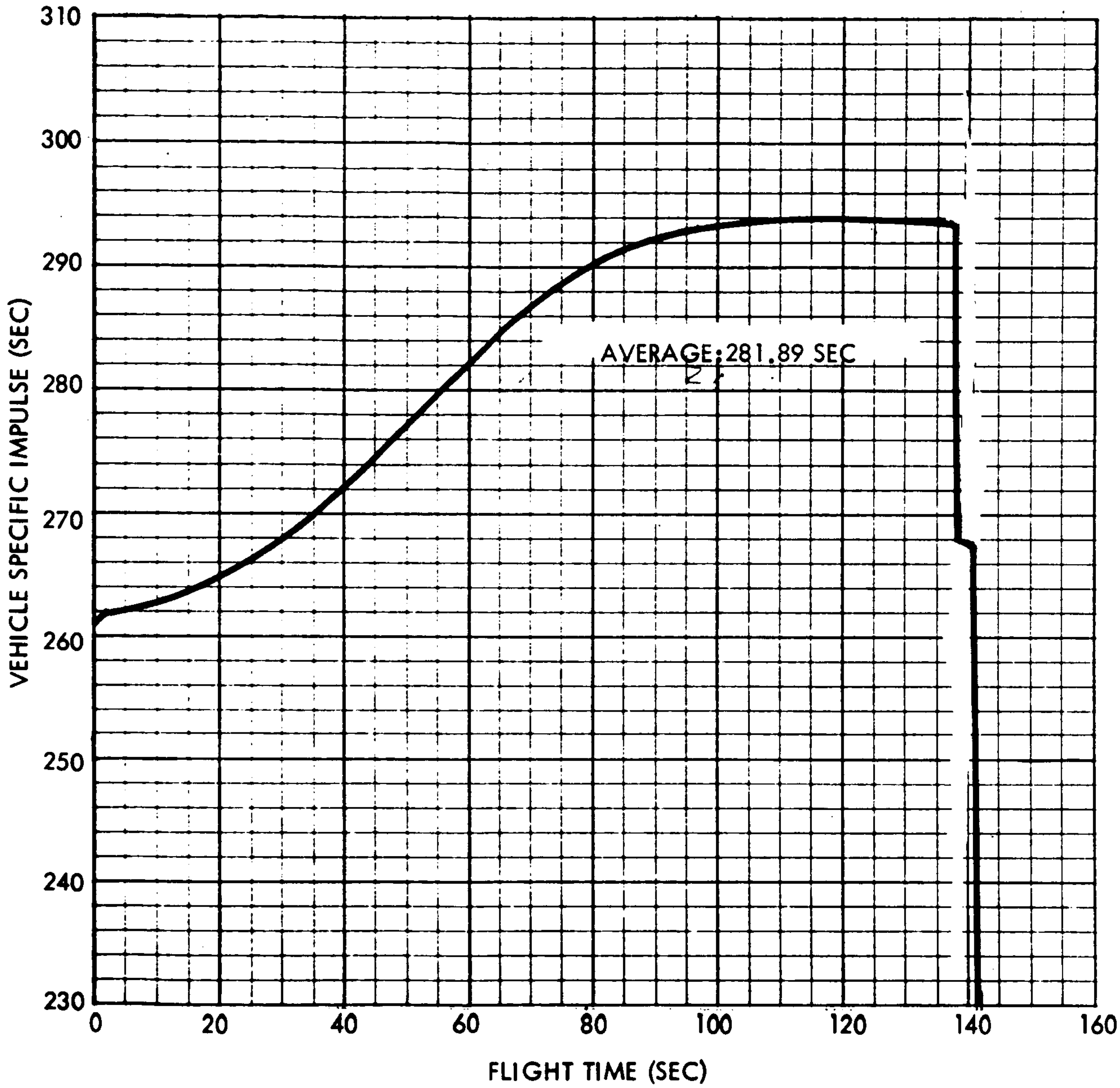

Figure 2. Vehicle Specific Impulse Versus Flight Time

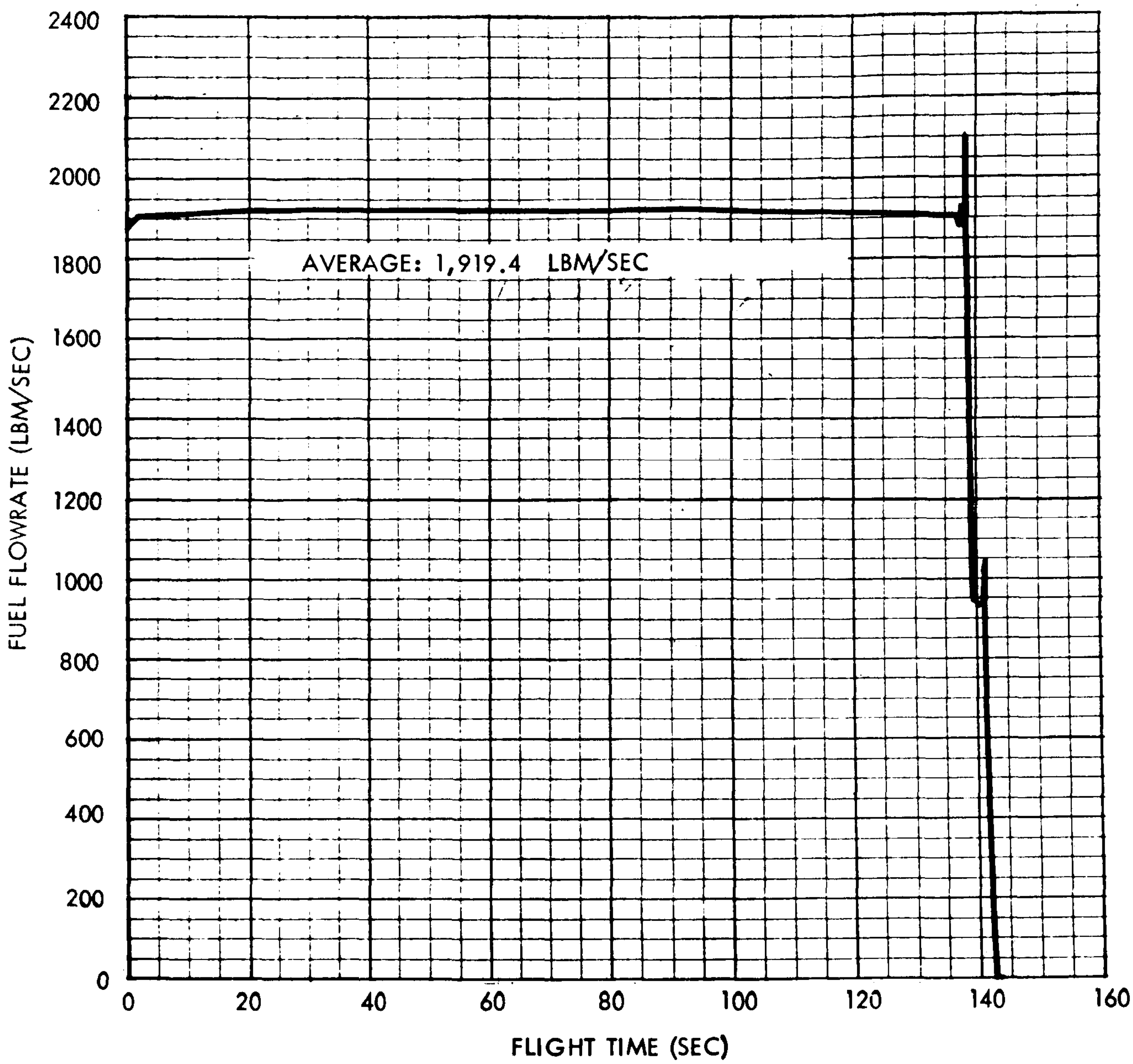

Figure 3. Total Vehicle Fuel Flowrate Versus Flight Time

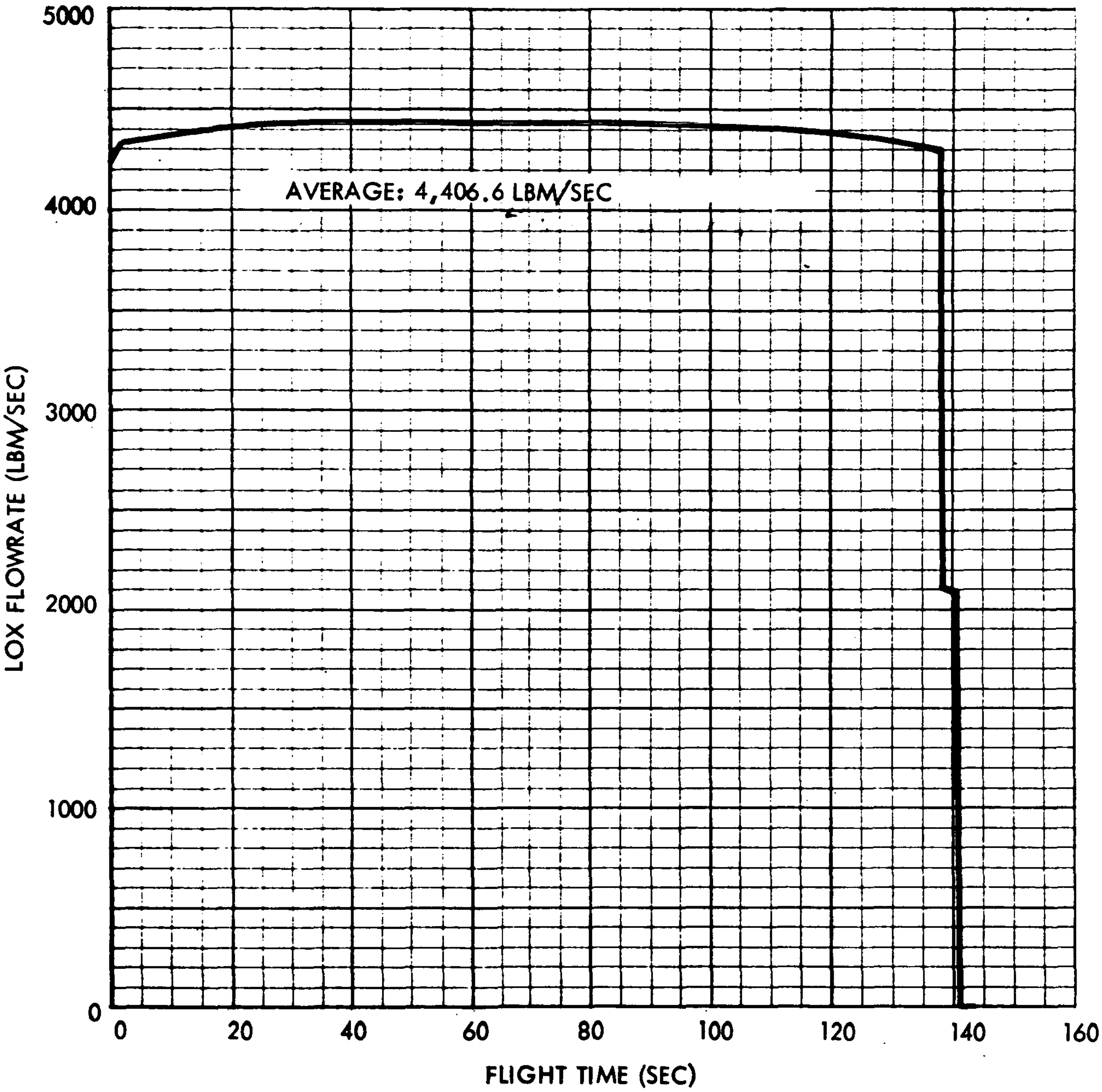

Figure 4. Total Engine LOX Flowrate Versus Flight Time

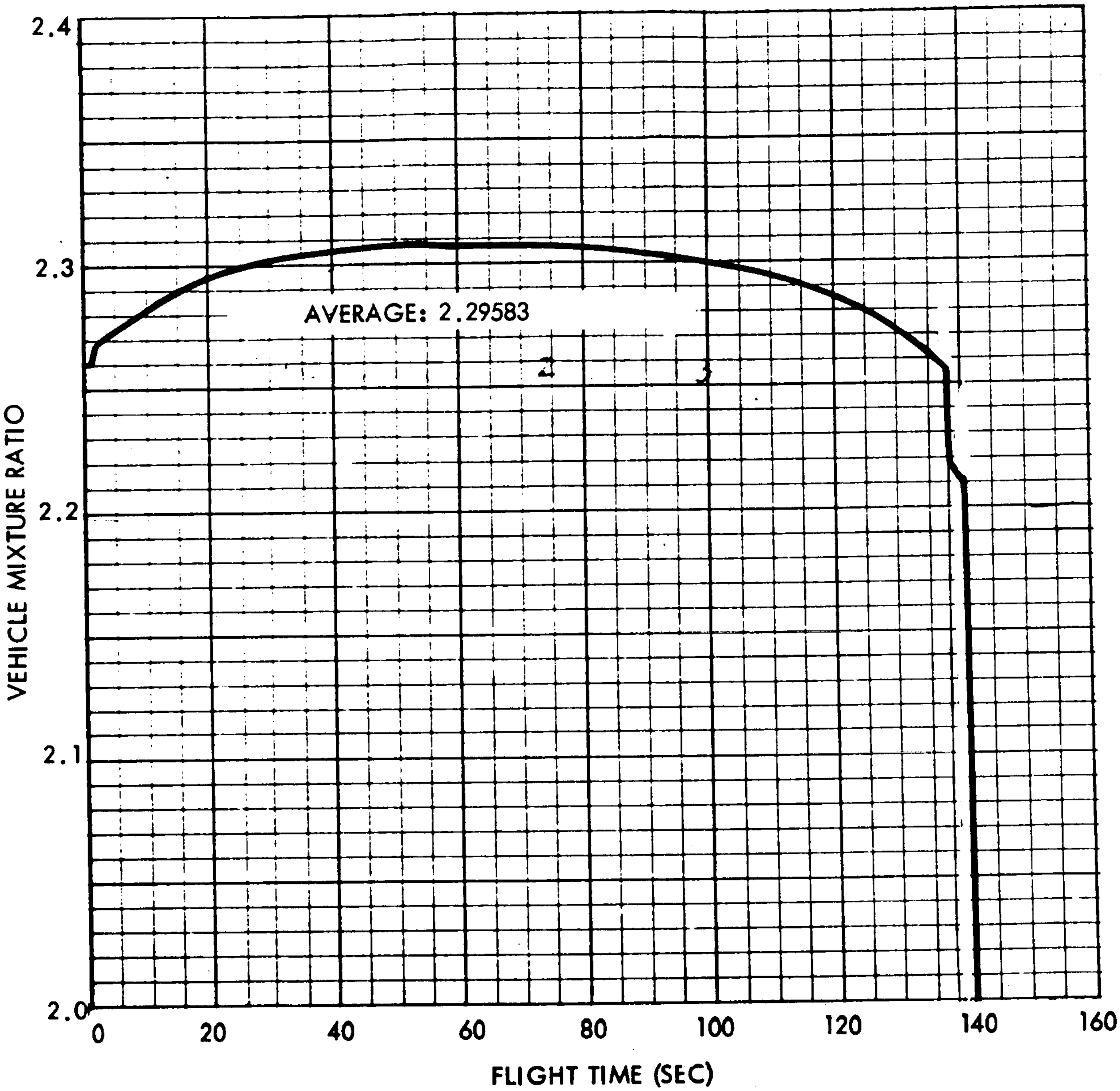

Figure 5. Vehicle Mixture Ratio Versus Flight Time

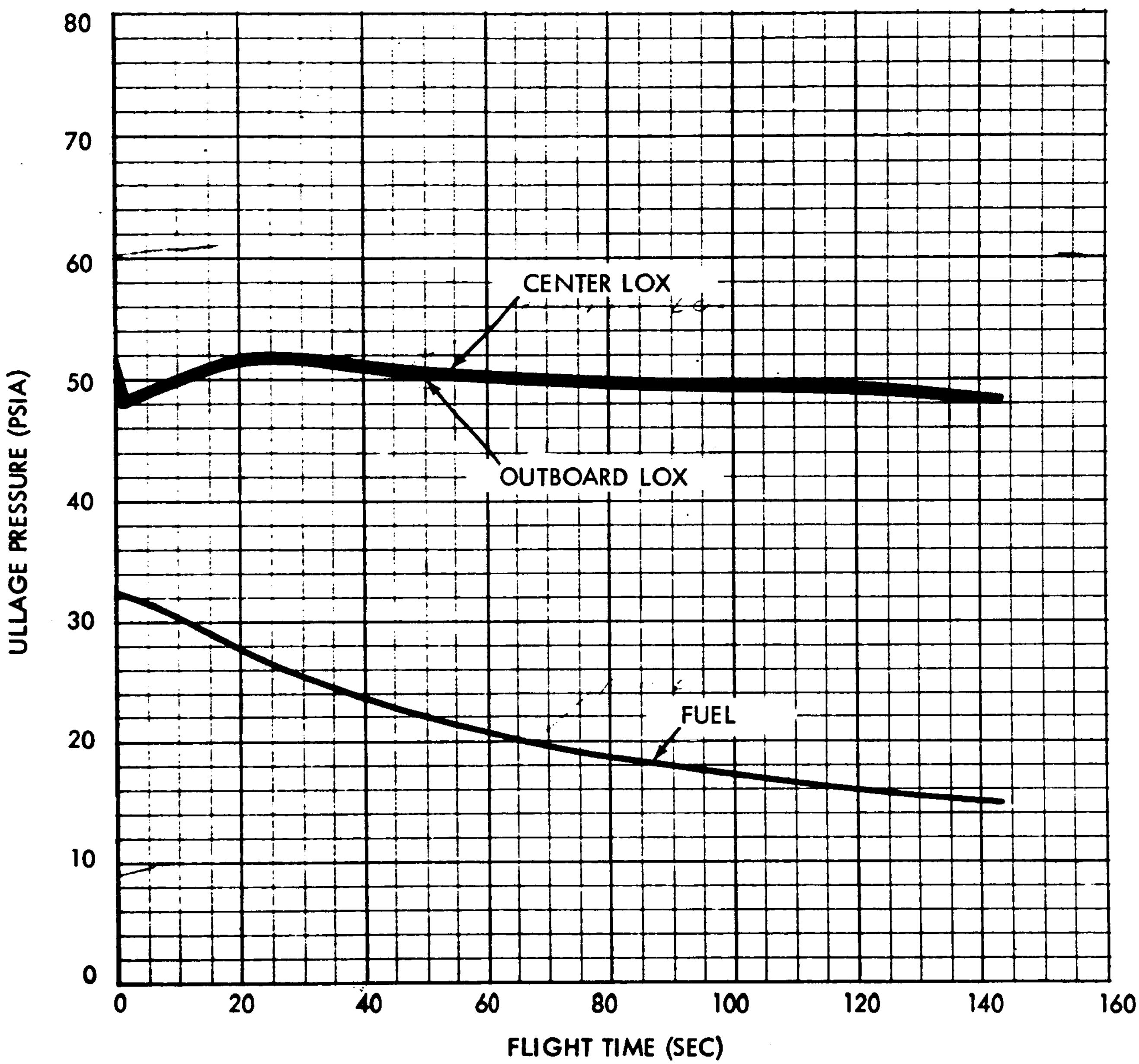

Figure 6. LOX and Fuel Tank Ullage Pressures Versus Flight Time

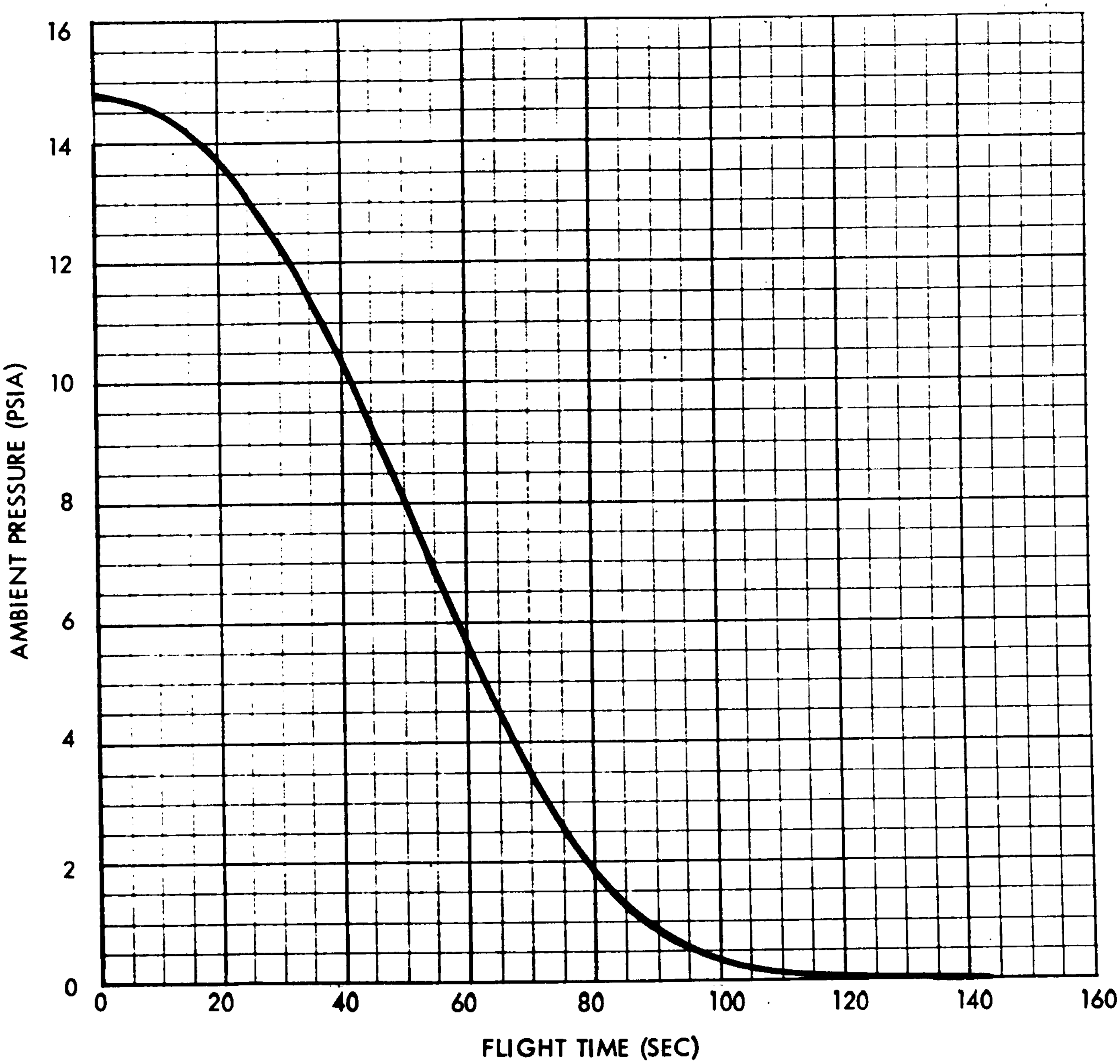

Figure 7. Ambient Pressure Versus Flight Time

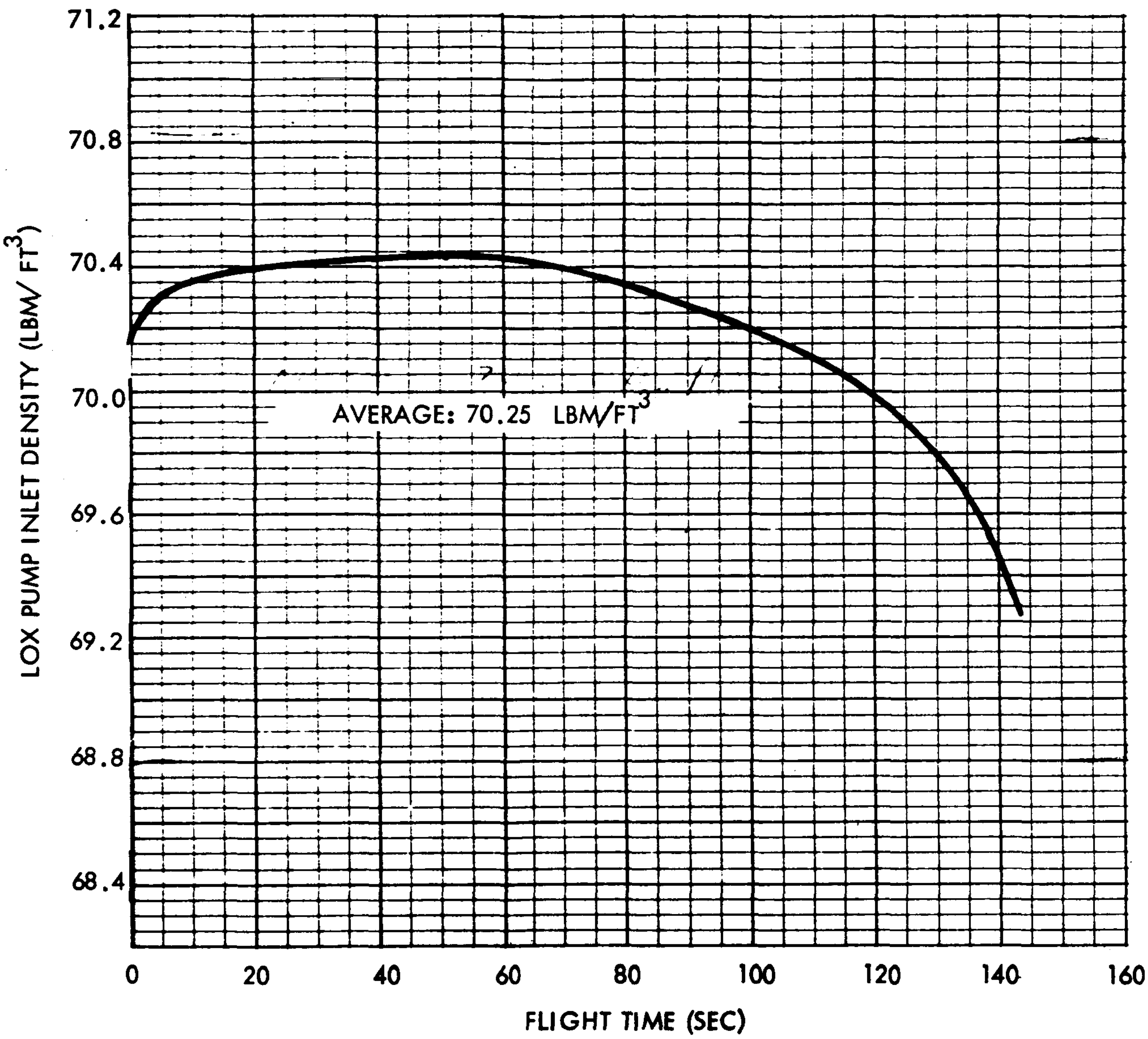

Figure 8. Engine LOX Pump Inlet Specific Weight Versus Flight Time

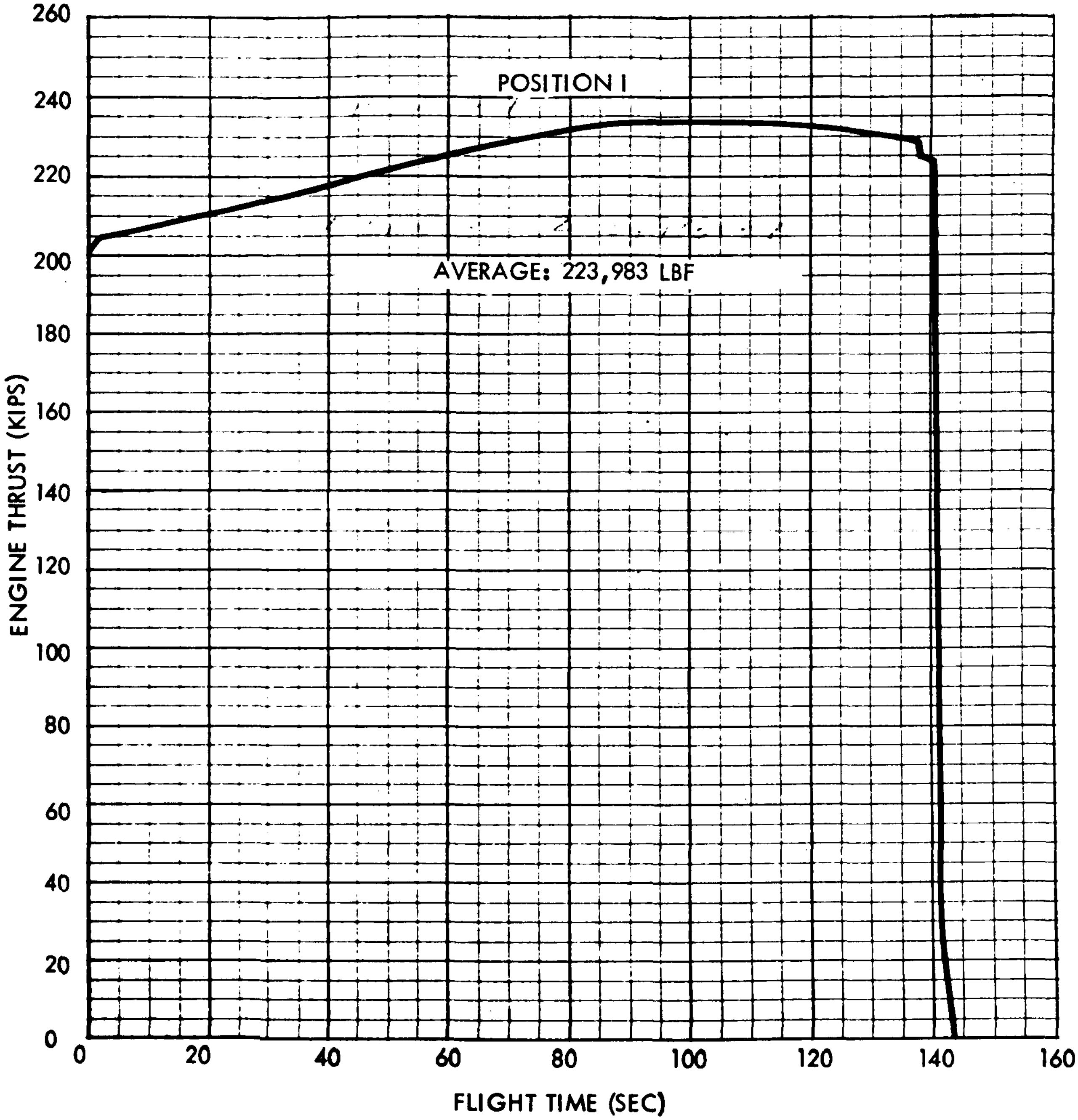

Figure 9. Typical Engine Thrust Versus Flight Time

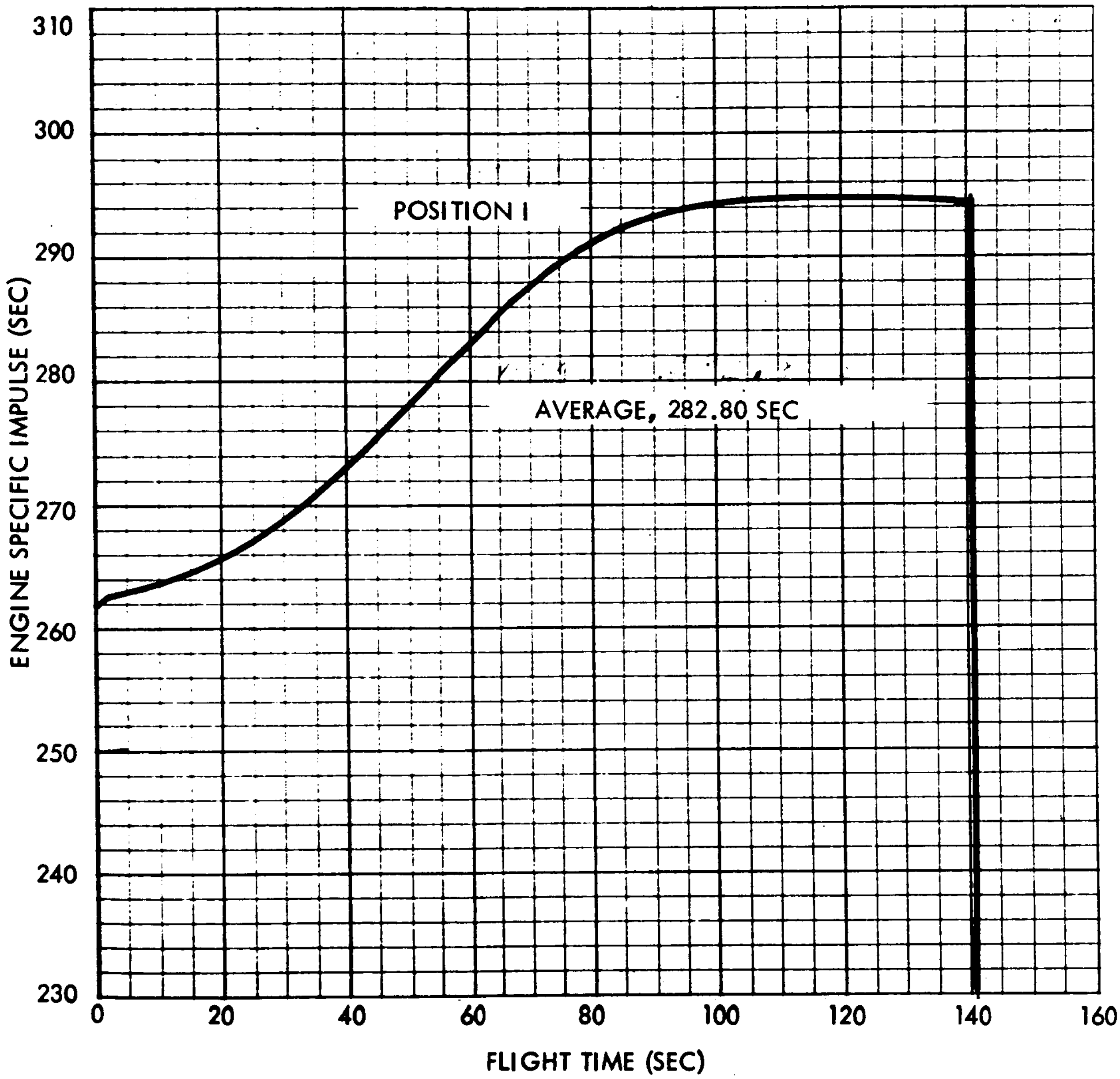

Figure 10. Typical Engine Specific Impulse Versus Flight Time

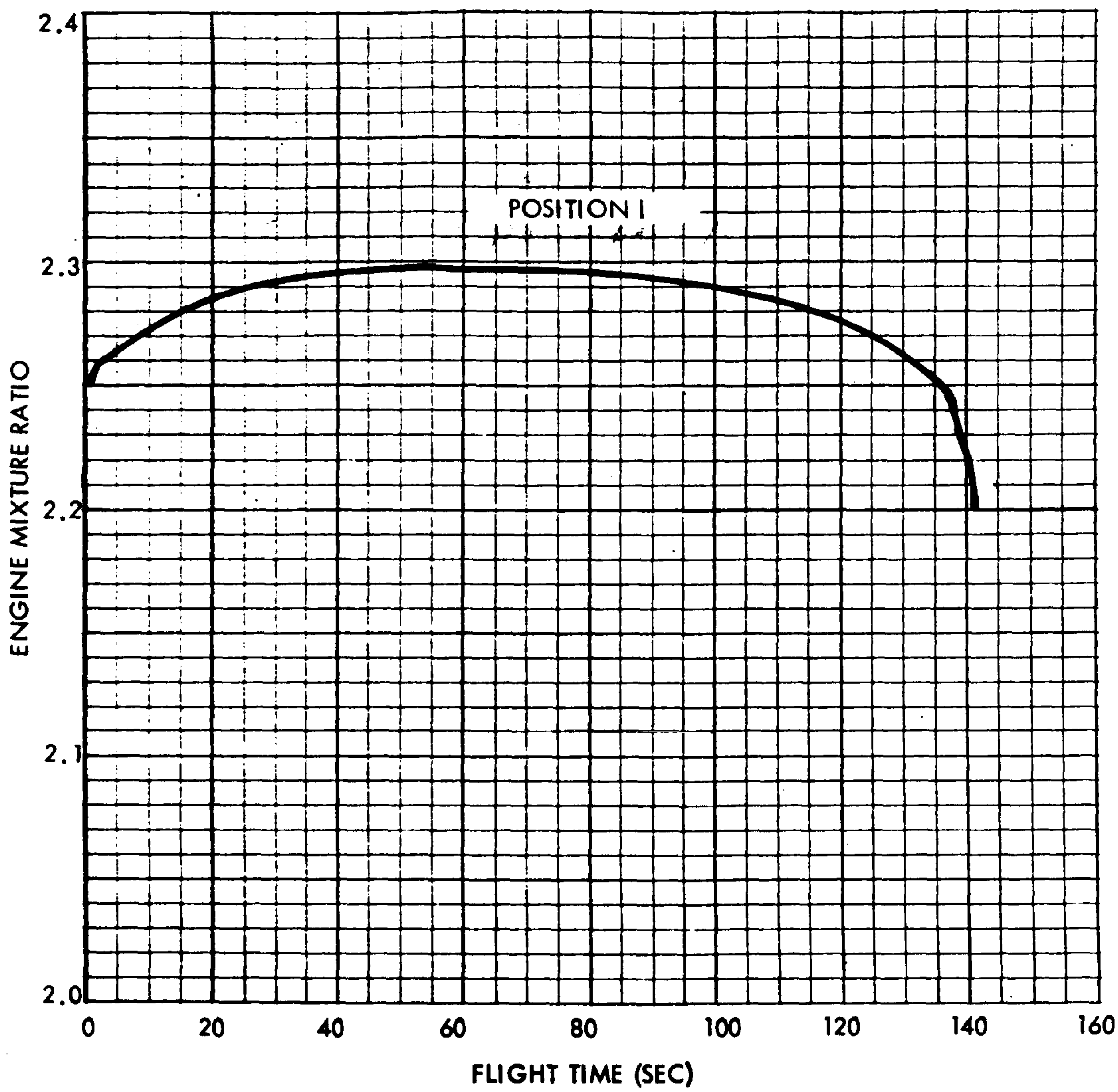

Figure 11. Typical Engine Mixture Ratio Versus Flight Time

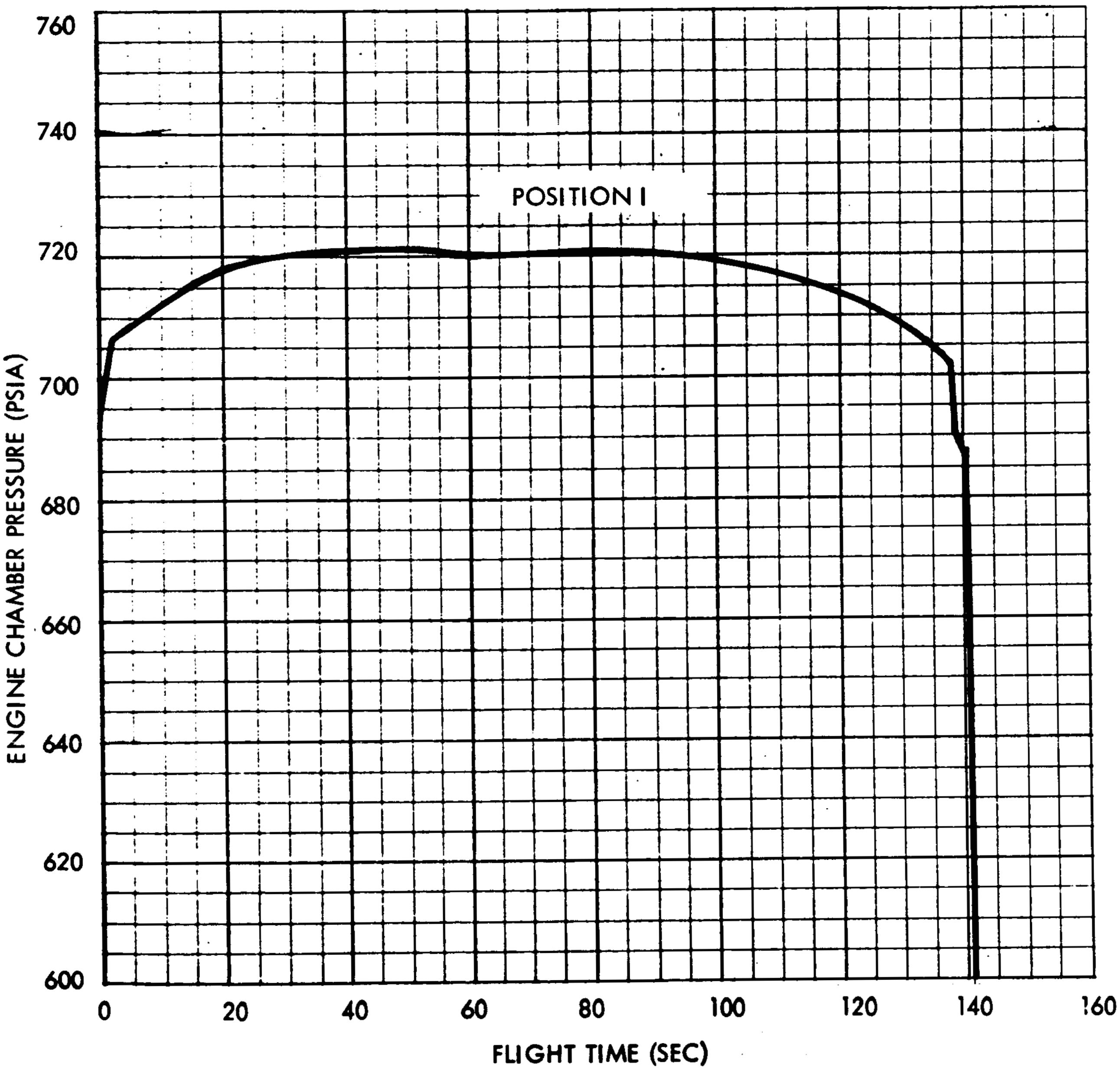

Figure 12. Typical Engine Chamber Pressure Versus Flight Time

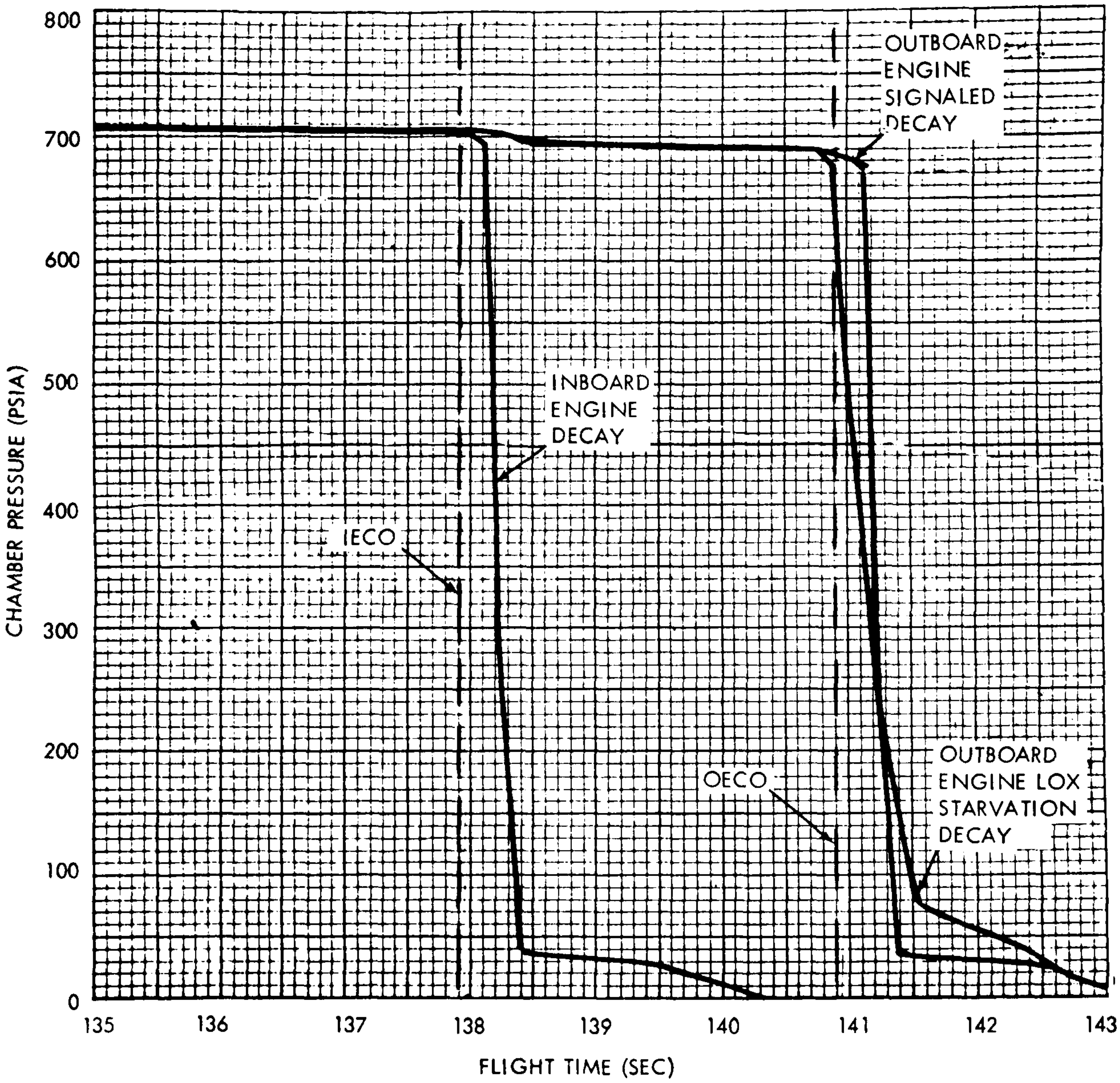

Figure 13. Typical Inboard and Outboard Engine Chamber Pressure Decay Relative to IECO

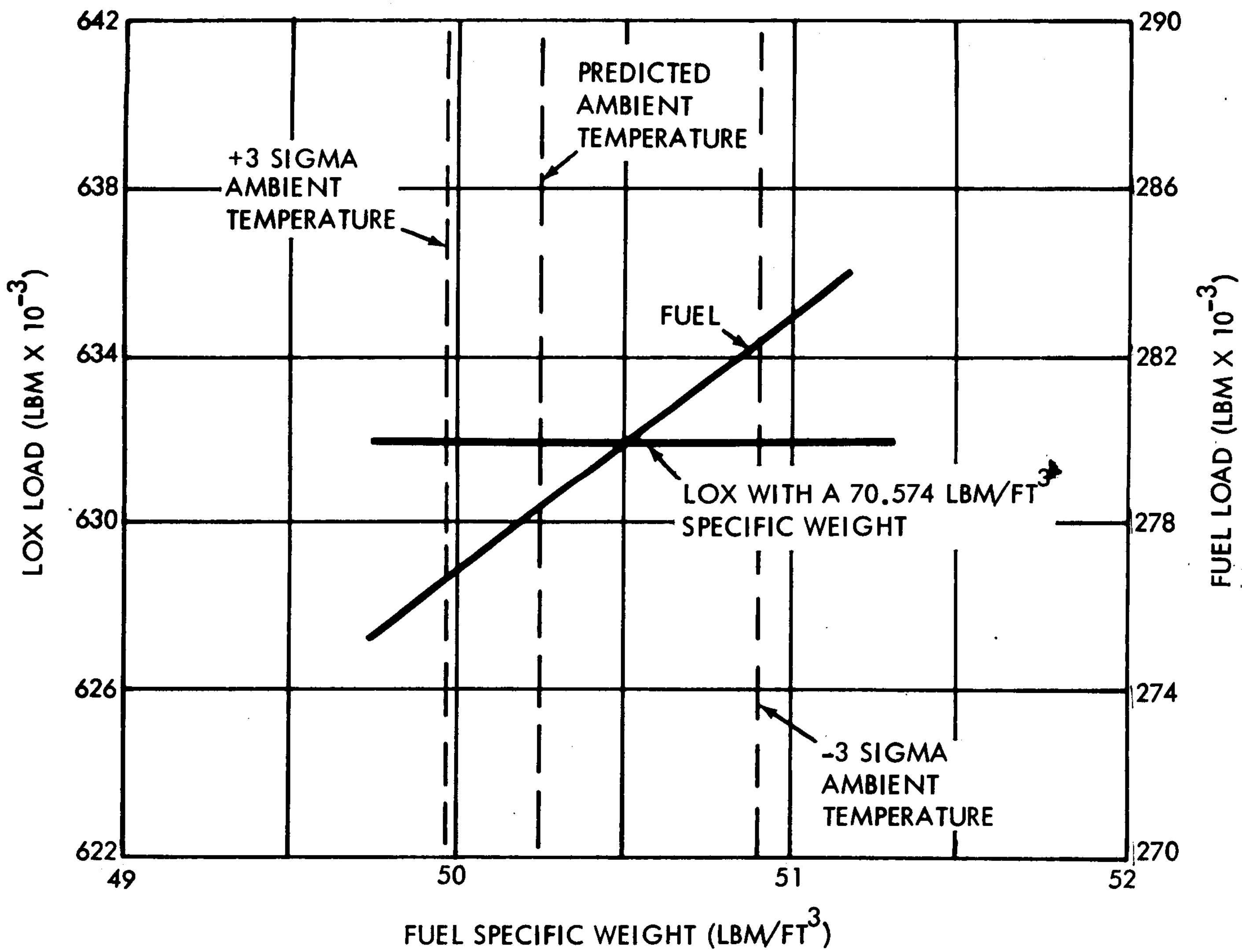

Figure 14. Propellant Load Versus Fuel Specific Weight

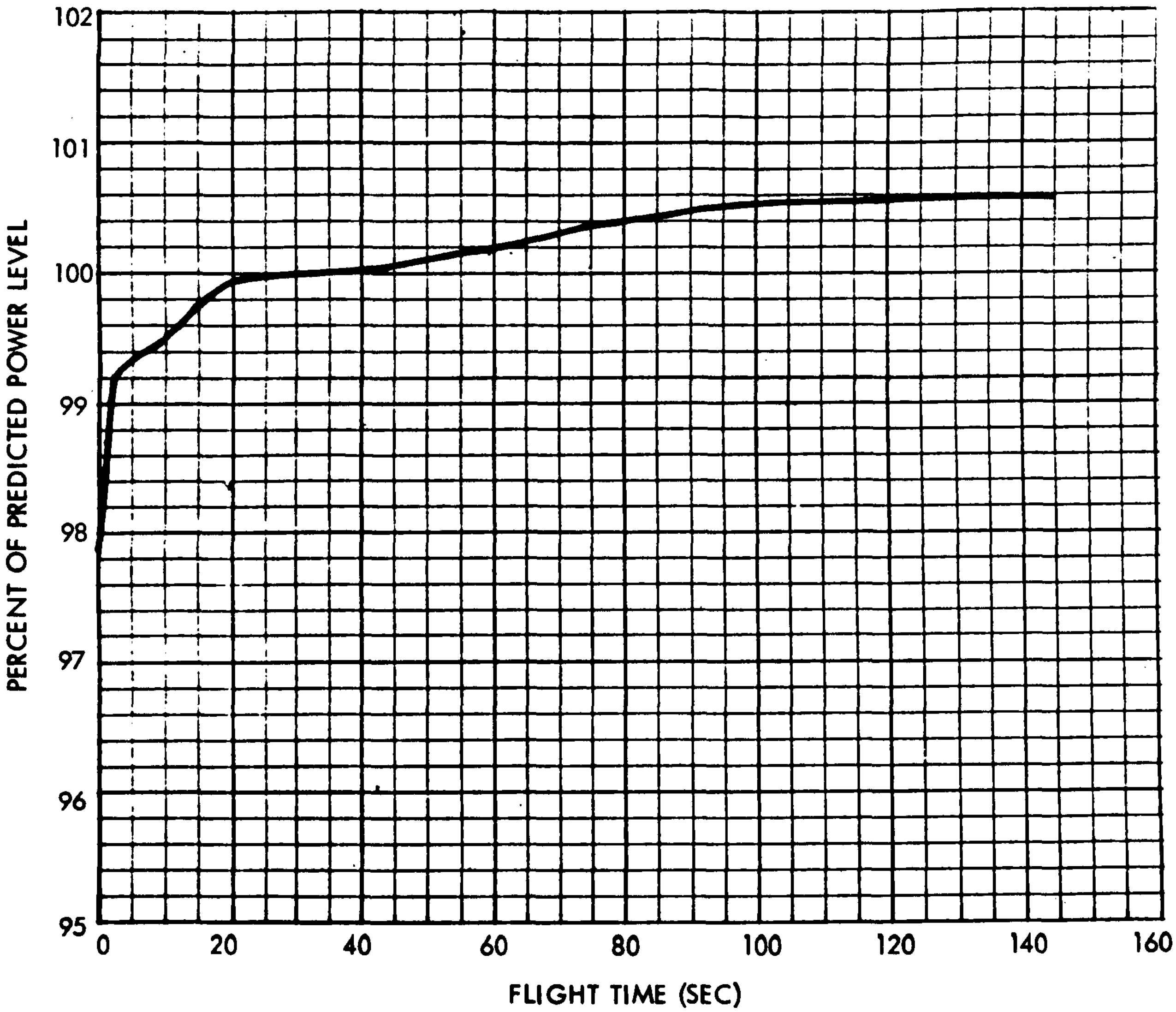

Figure 15. Predicted Sea Level Power Level Shift Versus Flight Time

REFERENCES

1. CCSD TR-P&VE-66-38, Flight Performance Prediction for Saturn AS-206 Propulsion System S-IB-6 Stage, January 10, 1967

2. CCSD TB-P&VE-68-280, S-IB Stage Criteria for AS-206 and AS-207 Flight Prediction, March 29, 1968

3. Rocketdyne Report SSM7114, Effects of Fuel Inlet Temperature Upon Engine Performance, H-1 Engine System, March 8, 1967

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